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The Association of Urbanicity with Infant Sleep Duration

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Abstract

Short sleep duration is associated with multiple adverse child outcomes. We examined associations of the built environment with infant sleep duration among 1226 participants in a pre-birth cohort. From residential addresses, we used a geographic information system to determine urbanicity, population density, and closeness to major roadways. The main outcome was mother's report of her infant's average daily sleep duration at 1 year of age. We ranked urbanicity and population density as quintiles, categorized distance to major roads into 8 categories, and used linear regression adjusted for socio-demographic characteristics, smoking during pregnancy, gestational age, fetal growth, and television viewing at 1 year. In this sample, mean (SD) sleep duration at age 1 year was 12.8 (1.6) hours/day. In multivariable adjusted analyses, children living in the highest quintile of urbanicity slept −19.2 minutes/day (95% CI: −37.0, −1.50) less than those living in the lowest quintile. Neither population density nor closeness to major roadways was associated with infant sleep duration after multivariable adjustment. Our findings suggest that living in more urban environments may be associated with reduced infant sleep.

Keywords

Sleep; urbanicity; population density; infancy; built environment

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INTRODUCTION

Short sleep duration in infancy is prevalent[1] and associated with multiple adverse outcomes including childhood obesity [2–4], behavioral and attention problems,[5] maternal depression[6] and elevated parental stress[7]. Recent studies suggest that the quality of sleep among young children is often compromised,[8] and that pediatric sleep disturbances frequently become chronic, with few children outgrowing the problem.[9,10] Several socio-environmental factors may influence infant sleep duration.[11] One such factor is the built environment.

The built environment refers to aspects of a person's surroundings that are human made or modified including housing, urban development, land use, transportation and commercial enterprises.[12] Built environment characteristics, assessed using geographic information systems (GIS), are associated with health outcomes and behaviors. For example, in a study of over 400,000 births in Eastern Massachusetts, Zeka et al. found a risk of reduced birth weight associated with greater exposure to traffic.[13] In a recent review of built environment factors, mixed land use, housing development, and levels of open space were all found to be associated with levels of physical activity among adults.[14] One advantage of GIS is the ability to categorize highly specific aspects of the built environment. For example, Li et al. found that neighborhood walkability and fast food restaurant density in Portland, Oregon correlated with older residents' blood pressure[15]. In another study of over 3,000 subjects of the Framingham Heart Study Offspring Cohort, closer proximity to fast food was associated with higher body mass index among women.[16] To date, there have been few published studies exploring the relationship between GIS variables that characterize the built environment and child health outcomes,[13,17] and none that we are aware of have examined sleep duration in infants.

The purpose of this study was to examine the associations of characteristics of the built environment with sleep duration in infancy. We were interested in examining environmental variables related to greater noise, light, air pollution, and temperature which can all adversely affect sleep duration. We hypothesized that increased urban land use, population density, and closer proximity to major roads would be associated with shorter sleep duration among infants at 1 year of age, and that socioeconomic status, biological and behavioral factors might confound this relationship.

METHODS

Subjects/Study Design

The subjects for this study were participants in Project Viva, a prospective cohort study of gestational factors, pregnancy outcomes, and offspring health.[18] We recruited women who were attending their initial prenatal visit from 1999 to 2002 at 8 urban and suburban obstetrical offices of a Harvard Vanguard Medical Associates, a multi-specialty group practice in eastern Massachusetts. Eligibility criteria included fluency in English, gestational age less than 22 weeks at the initial prenatal clinical appointment, and singleton pregnancy. Details of recruitment and retention procedures are available elsewhere. [18]

Of the 2,128 women who delivered a live singleton infant, 2119 provided their address at enrollment in the first trimester and 1768 agreed to enroll their infants for follow up. We geocoded the residential addresses to obtain our main exposures. Mothers completed a mailed questionnaire at 1 year postpartum on which they reported child sleep duration. One-year sleep outcome data were available for 1226 infants, who comprise the current analytic sample. Comparison of the 1226 participants in this analysis with the 902 excluded participants showed some differences. For example, excluded vs. included participants were more likely to be African-American (24.3% vs 11.0%), exposed to maternal smoking during pregnancy (17.7% vs 9.6%) and live in households with annual income less than $40,000 per year (22.5% vs 11.2%).

Institutional review boards of participating institutions approved the study. All procedures were in accordance with the ethical standards for human experimentation established by the Declaration of Helsinki.

Measurements

Main Exposure—From residential addresses collected at enrollment in the first trimester of pregnancy, we used a geographic information system (GIS) to determine our built environment exposures. All GIS analyses were performed using ArcGIS 9.3 (ESRI, Redlands, CA) in the Massachusetts State Plane projection, North American Datum 1983. The variables included 1) urbanicity; 2) population density; and 3) closeness to primary highways.

We defined urbanicity as the proportion of urban land use within 1 km of the mother's residential address. This categorization makes use of nationwide land use data derived from satellite images with approximately 30 m resolution (the Multi-Resolution Land Characteristics Consortium (www.mrlc.gov) 2001 National Land Cover Data Set). We considered low, medium and high-intensity developed land uses to be urban. Following an approach originally developed by Yanosky et al. for the Nurses' Health Study[19], we used the ESRI ArcGIS® Spatial Analyst extension to calculate a surface with 30 m resolution representing the proportion of urban land use within 1 km. We then interpolated values for urbanicity at each mother's residential address from this surface. Thus, urbanicity measures land use and defines urban vs. suburban environments and captures more information than just simply the size of the population in a certain area.

We defined population density as the 2000 census block group population per square kilometer of dry land. To estimate distance to major roadways, we used ESRI Streetmap 9.2 to calculate the minimum distance in meters from each geocoded address to the nearest major roadway. We defined major roadways based on US Census Feature Class Codes and used in our analyses the roads that were potentially most associated with traffics, light, and noise, e.g. A1 (primary roads with limited access) and A2 (primary roads without limited access) roads.

Outcome Measures—At 1-year postpartum, we asked mothers, "In the past month, on average, for how long does your child sleep in a usual 24-hour period? Please include morning naps, afternoon naps, and nighttime sleep." Mothers provided responses in hours and minutes. Previous studies have recently validated parental report of infant sleep duration by associations of both actigraphic and parental report of sleep duration with elevated infant weight-for-length. [20]

Other Measures—Using a combination of self-administered questionnaires and interviews, we collected information about maternal age, education, parity, marital status, prenatal smoking (never, former, during pregnancy), household income, and child's race/ethnicity. We obtained gestational age and infants' birth weights from medical records. We determined birth-weight-for-gestational-age (fetal growth) z-score according to a 1999–2000 US national birth reference.[21] At 1 year, we asked mothers to report the number of hours and minutes their children watched TV or videos in the past week.

Statistical Analysis

We first examined descriptive statistics for our sample characteristics, exposures, and main outcomes. Next, we examined the bivariate relationships of our built environment exposures with our main outcome. We ranked urbanicity and population density into quintiles and categorized closeness to class 1 or 2 roads into 8 categories to examine linearity of associations with sleep duration and because the distributions were highly right skewed for all 3 exposures variables.

We used multivariable linear regression models to examine the associations between each exposure variable in quintiles or categories with sleep duration at 1 year. In multivariable models, we included only those covariates that were of *a priori* interest or confounded associations of our main built environment exposures with sleep duration. Model 1 was adjusted only for child sex. In Model 2, we additionally adjusted for socio-demographic characteristics, including maternal age, race/ethnicity, parity, education, marital status; and household income. In Model 3, we further adjusted for potential biologic and behavioral confounders including maternal smoking during pregnancy; infant gestational age and fetal growth, and television/video viewing at age 1 year.

Finally, because exposure to built environment variables may vary by socioeconomic position, we investigated for effect modification by maternal education and household income using multiplicative interaction terms, and we performed analyses stratified by mothers' education and household income. We conducted all analyses using SAS, version 9.2 (Cary, North Carolina).

RESULTS

At 1 year of age, children slept a mean of 12.8 (SD 1.6) hours/day. Characteristics of urbanicity, population density, and closeness to major roadways are summarized in Table 1. Correlations among the built environment exposures with each other and with infant sleep duration are provided in Table 1. Urbanicity and population density were strongly correlated (r =0.73) but both were only weakly negatively correlated with closeness to major roadways (Table 1). Other characteristics of the study participants are summarized in Table 2. Mothers living in census block groups with the highest v. lowest quintile of urbanicity were less likely to have a college degree (65% vs 79%; chi-square p=0.02), to have household incomes > $70,000 (56% vs 81%; chi-square p=<0.0001), to be married or co-habitating (91% vs 98%; chi-square p=0.003), and to be white (62% vs 91%; chi-square p=<0.0001). In addition, more white mothers vs. mothers of non-white race/ethnicities lived in the highest v. lowest category of closeness to Class 1 or 2 Roads (84% vs 62%; chi-square p<0.0001).

In bivariate analyses (Table 2), mean infant sleep duration was lower with higher quintile of urbanicity. Mean (SD) hours/day of sleep was 13.1 (1.6) in quintile 1 and 12.5 (1.6) in quintile 5 (ANOVA p=0.001). We observed a similar overall pattern of lower sleep duration with higher quintile of population density. Mean (SD) hours/day of sleep was 13.0 (1.6) in quintile 1 and 12.7 (1.5) in quintile 5 of population density (ANOVA p=0.03). In bivariate analyses, children living closest to Class 1 or 2 Roads (< 50 meters) had slightly shorter sleep duration than those living furthest away, but the associations of closeness to roads with infant sleep duration did not appear to be linear.

We show multivariable results in Tables 3 and 4. In Model 1, adjusted only for child sex, quintile of urbanicity was negatively associated with infant sleep duration. Being in quintile 5 v. quintile 1 of urbanicity was associated with about over 30 minutes/day less sleep at 1 year (β −33.5 [95% CI −50.8, −16.2]). Adjustment for socioeconomic variables including maternal age, education, parity, marital status, and household income substantially attenuated the observed estimates (β −17.3 [95% CI −34.9, 0.33] for quintile 5 v. quintile 1). Further adjustment for smoking during pregnancy, gestational age at birth, fetal growth, and TV viewing at 1 year of age did not materially affect the estimates (β −19.2 [95% CI −37.0, −1.50] for quintile 5 v. quintile 1). Additionally, television viewing was an independent predictor of sleep duration: each 1 hour/day increment in television viewing at 1 year of age was associated with 5.89 minutes/day (95% CI: −9.66, −2.12) less sleep in a 24 hour period. Offspring of black (β −43.1 [95% CI −63.5, −22.8), Hispanic (β −43.9 [95% CI −68.0, −19.8) or other race/ethnicity mothers (β −21.4 [95% CI −41.1, −1.80) slept fewer hours at 1 year of age than offspring of white mothers.

In models adjusted only for child sex, compared to children living in the 1st quintile of population density, we observed shorter sleep duration in the 2nd through 5th quintiles of population density. However, after adjustment for socioeconomic variables, the observed associations became null (Table 3). Closeness to Class 1 or 2 roads was not associated with infant sleep duration in unadjusted or multivariable adjusted models (Table 3).

We did not observe effect modification by maternal education or household income for any of our exposure-outcome associations (results not shown).

DISCUSSION

In this prospective study of 1226 mother-infant pairs with information regarding the built environment in early life, we found that infants who lived in more urbanized neighborhoods had shorter sleep duration. The observed associations were partially explained by adjustment for socio-demographic characteristics. Further adjustment for potential behavioral and biological intermediates including fetal growth, gestational age, maternal smoking during pregnancy, and television viewing did not substantially change the observed associations. Although living in densely populated areas and living at shorter distances to major roadways appeared to be associated with shorter sleep duration, these associations were largely explained by socioeconomic characteristics of participants living in those areas.

To the best of our knowledge, this is the first study to report on associations of aspects of the built environment with sleep duration in infancy. While much is known about the role of parental behavior and cognition in influencing infant sleep, less is known about the social and environmental context influencing sleep in this age group.[22,23] Although the difference of 20 minutes in sleep duration may appear small in magnitude, recent studies have shown that even small restrictions in infant sleep duration are associated with perceived difficult infant temperament, increased likelihood of later behavior problems, compromised cognitive abilities and increased body weight.[24] In addition, if less sleep tracks throughout childhood, the observed small magnitudes of effect could be additive throughout the child’s lifecourse. In this context of potential chronic sleep loss, even risk factors during infancy may be clinically relevant and merit awareness by clinicians. Our findings suggest that the built environment may be associated with health even in the earliest stages of life.

Several potential mechanisms may underlie the association between the built environment and sleep duration. Exposure to road-traffic and transportation-related noise[25], electric lighting[26] and air pollution[27] may reduce sleep duration. Noise, light, air pollution, and higher temperature are each prominent features of the urban landscape[28–30] and may therefore represent intermediate pathways in the relationship between urbanicity and sleep duration in infancy. Living in more urban settings may also produce stress through increased hypothalamic-pituitary-axis (HPA) activation, which may in turn exert downstream effects on infant sleep architecture. In their analysis of stress and neighborhood environments in

Philadelphia, Matthews et al. found a 50% increase in self-reported stress among residents living in a neighborhood with a hazardous waste processing facility such as a landfill or incinerator.[31] Prior work has also established road-traffic noise as a contributor to stress[28], and children exposed to increased traffic-related noise have been found to have elevated overnight cortisol[32] and higher resting systolic blood pressure.[32,33] Among preschool children, increased HPA activation is associated with elevated stress[34] as well as poor quality sleep[35]. In this study, however, we were unable to measure noise, air pollution, temperature, ambient light levels, or HPA axis activation directly, so these mechanisms remain speculative.

We found that markers of socioeconomic position confounded the relationships of urbancity and population density with infant sleep duration. Socioeconomic position is highly interrelated with the built environment[36] and both individual and neighborhood level socioeconomic position may impact sleep characteristics. At the individual level, low socioeconomic position has been associated with higher levels of chronic stress, with poor sleep quality helping to explain the observed associations[37]. Patel et al. have described a ‘sleep disparity’, whereby poor sleep quality correlates strongly with poverty and racial/ethnic minority status among adults.[38] From prospectively gathered data on preschool children, Hale et al. reported later bedtimes among Black and Hispanic children compared to white children, and found that low maternal education, greater household size, and poverty were associated with decreased use of bedtime routines.[39] As with individual and household level effects, socioeconomic position may adversely impact sleep at the neighborhood level through neighborhood disadvantage and disorder. Residence in a neighborhood that is perceived as noisy, unclean, and crime-ridden was associated with poorer quality sleep among a sample of Texas adults, [40] and severe neighborhood disadvantage was associated with a sleep disorder, obstructive sleep apnea among a sample of 8 to 11 year old children after adjustment for household level socioeconomic position.[41] Thus, socioeconomic position is a plausible and important confounder of the association between the built environment and sleep.

Our study had several strengths including our ability to adjust analyses for a number of potential socioeconomic, biologic, and behavioral variables that might be independently associated with sleep duration. Several limitations also exist. Although mothers had diverse racial/ethnic backgrounds, their education and income levels were relatively high. Our results may therefore not be generalizable to more socioeconomically disadvantaged populations. In addition, given the differences among the children included in the analysis and those for which we did not have available outcomes data, our findings may be subject to selection bias. Second, while we had measures of several built environment exposures, we did not collect information on factors such as air pollution or noise levels that could help examine potential mechanisms of action. Furthermore, we did not collect other measures of infant sleep quality, e.g. number of nighttime awakenings, sleep location, bedtime routines, co-sleeping, crowding, or parental perceptions of sleep, all of which may be related to sleep duration. Third, we measured sleep duration by parental report rather than using an objective measure of sleep such as accelerometers or diaries. Finally, an additional limitation of any study that uses an observational design is that the association between the primary exposure and the outcome of interest may be mediated by factors not measured or not considered. Residual confounding by variables we did not measure, e.g. noise, light, air pollution, stress, or maternal depression, could explain our observed associations.

In conclusion, the living in more urban environments is associated with shorter infant sleep duration. Further studies are needed to clarify mechanisms relating the built environment to infant sleep characteristics. Considering the built environment along with family and individual behaviors may help inform interventions to support sufficient, good quality sleep during infancy.

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Research Highlights

- Short sleep duration is a risk factor for multiple adverse pediatric outcomes.
- Built environment characteristics, including urbanicity, can adversely affect sleep duration.
- Infants living in neighborhoods that were more urban had shorter sleep duration.
- Our findings suggest that the built environment may influence infant sleep.

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Table 1

Distributions of infant sleep duration at 1 year and measures of the built environment: (urbanicity, population density, and closeness to Class 1 or 2 roads), and their correlations. Data from 1226 participants in the Project Viva Cohort in Massachusetts.

	Sleep duration at age 1 year (hours/day)	**Urbanicity (units)**	**Population Density (units)**	**Closeness to Class 1 or 2 Roads (meters)**
Mean (SD)	12.8 (1.6)	779 (284)	4597 (5204)	1730 (1908)
Median (SE)	13 (0.05)	874 (8.1)	2703 (149)	1078 (54.5)
Range	5 – 19	0 – 1105	67 – 42,100	10 – 12,941
Built Environment Exposures	**Sleep duration at age 1 year (hours/day)**	**Urbanicity (quintiles)**	**Population Density (quintiles)**	**Closeness to Class 1 or 2 Roads (categories*)**
	Spearman Correlation Coefficients r (p-value)			
Urbanicity	−0.14 (<0.0001)	1.0		
Population Density	−0.09 (0.002)	0.73 (<0.0001)	1.0	
Closeness to Class 1 or 2 Roads	0.04 (0.14)	−0.28 (<0.0001)	−0.35 (<0.0001)	1.0

*Categories were <50 meters, 50 to < 100 meters, 100 to < 200 meters, 200 to < 400 meters, 400 to < 600 meters, 600 to < 1000 meters, 1000 to < 2000 meters, ≥ 2000 meters.

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Table 2

Characteristics of 1226 Mothers and Infants in Project Viva, According to Quintile of Urbanicity.

		Quintile of Urbanicity					
	Overall	**1**	**2**	**3**	**4**	**5**	***p****
	N (%) or Mean (SD)						
Urbanicity (unit)	779 (284)	326 (167)	710 (68)	889 (37)	993 (24)	1072 (17)	
Mother and Family							
Maternal age at enrollment (years)	32.3 (4.9)	33.3 (4.1)	32.4 (4.8)	32.3 (4.9)	32.4 (5.1)	31.2 (5.6)	0.0001
Pre-pregnancy body mass index (kg/m^2)	24.5 (5.1)	24.2 (4.4)	24.6 (5.3)	24.6 (4.9)	24.6 (5.3)	24.6 (5.4)	0.80
College graduate or more (%)	892 (73%)	213 (79%)	181 (73%)	183 (73%)	171 (73%)	138 (65%)	0.02
Household income > $70,000/year (%)	768 (67%)	209 (81%)	154 (66%)	148 (64%)	144 (67%)	109 (56%)	<0.0001
Nulliparous (%)	613 (50%)	125 (46%)	106 (43%)	128 (51%)	119 (51%)	130 (61%)	0.002
Married or co-habitation (%)	1148 (94%)	266 (98%)	236 (95%)	229 (92%)	215 (92%)	193 (91%)	0.003
Mother smoked during index pregnancy (%)	114 (10%)	20 (8%)	23 (10%)	24 (10%)	19 (8%)	26 (13%)	0.39
White (%)	915 (75%)	246 (91%)	199 (80%)	185 (74%)	147 (63%)	132 (62%)	<0.0001
Child and Home Environment							
Boy (%)	626 (51%)	141 (52%)	129 (52%)	122 (49%)	119 (51%)	111 (52%)	0.94
Birth Weight (kg)	3.50 (0.57)	3.53 (0.58)	3.50 (0.56)	3.51 (0.51)	3.49 (0.61)	3.45 (0.58)	0.60
Gestational age at birth (weeks)	39.5 (1.8)	39.4 (1.9)	39.5 (1.8)	39.6 (1.7)	39.4 (2.0)	39.6 (1.8)	0.47
Birth weight for gestational age z-score (units)	0.22 (0.94)	0.32 (0.96)	0.21 (0.96)	0.24 (0.89)	0.25 (0.94)	0.08 (0.96)	0.07
Breastfeeding duration at 1 year (months)	6.4 (4.5)	5.9 (4.4)	6.3 (4.5)	6.3 (4.4)	6.7 (4.7)	6.9 (4.6)	0.14
Television viewing at 1 year of age (hrs/day)	1.2 (1.5)	1.3 (1.4)	1.2 (1.5)	1.3 (1.6)	1.1 (1.4)	1.1 (1.3)	0.53
Sleep duration at 1 year of age (hrs/day)	12.8 (1.6)	13.1 (1.6)	12.9 (1.5)	12.7 (1.6)	12.6 (1.7)	12.5 (1.6)	0.001

*P values are from chi-square for categorical variables and from ANOVA for continuous variables.

Table 3

Associations of Built Environment Exposures with Infant Sleep Duration. Data From Multivariable Analyses† of 1226 Infants Participating in Project Viva.

Exposures	N	Estimates of sleep duration at 1 year (minutes/day), by multivariable model — Effect estimate (95% Confidence Interval)		
		Model 1	Model 2	Model 3
Urbanicity				
Quintile 1	271	0.00 (ref)	0.00 (ref)	0.00 (ref)
Quintile 2	248	−10.2 (−26.8, 6.44)	−5.04 (−21.4, 11.35)	−3.49 (−19.8,12.86)
Quintile 3	250	−20.0 (−36.6, −3.44)	−11.2 (−27.7, 5.25)	−11.4 (−27.8, 5.07)
Quintile 4	234	−29.2 (−46.1, −12.3)	−15.4 (−32.3, 1.59)	−11.9 (−28.9, 5.05)
Quintile 5	214	−33.5 (−50.8, −16.2)	−17.3 (−34.9, 0.33)	−19.2 (−37.0, −1.50)
Population Density				
Quintile 1	275	0.00 (ref)	0.00 (ref)	0.00 (ref)
Quintile 2	259	−19.3 (−35.7, −2.79)	−14.6 (−30.7, 1.44)	−13.1 (−29.2, 2.89)
Quintile 3	241	−22.1 (−38.8, −5.32)	−11.5 (−28.0, 5.08)	−9.17 (−25.7, 7.38)
Quintile 4	228	−25.7 (−42.8, −8.70)	−8.00 (−25.3, 9.24)	−8.25 (−25.5, 8.99)
Quintile 5	214	−17.9 (−35.2, −0.56)	1.69 (−15.9,19.29)	−0.01 (−17.7,17.70)
Closeness to Class 1 or 2 Roads				
< 50 meters	45	0.0 (ref)	0.0 (ref)	0.0 (ref)
50 to < 100 meters	34	−9.18 (−52.4,33.98)	−15.9 (−58.1,26.27)	−24.4 (−66.3,17.37)
100 to < 200 meters	81	−16.4 (−51.7,18.89)	−17.2 (−51.8,17.38)	−19.8 (−54.3,14.70)
200 to < 400 meters	120	5.94 (−27.3,39.16)	3.82 (−28.8,36.39)	−3.44 (−35.8,28.91)
400 to < 600 meters	122	−12.6 (−45.8,20.58)	−15.8 (−48.4,16.72)	−17.7 (−50.2,14.70)
600 to < 1000 meters	173	−23.2 (−55.0, 8.56)	−25.9 (−56.9, 5.24)	−28.1 (−58.9, 2.72)
1000 to < 2000 meters	274	−9.18 (−39.8,21.39)	−12.2 (−42.2,17.73)	−17.1 (−46.8,12.70)
≥ 2000 meters	377	1.93 (−28.1,31.92)	−6.65 (−36.2,22.87)	−10.2 (−39.4,19.04)

†Model 1 is adjusted only for child sex. Model 2 is Model 1 + race/ethnicity, parity, education, household income, marital status, and maternal age. Model 3 is Model 2 + smoking during pregnancy, gestational age, fetal growth, and TV viewing at 1 year.

Table 4

Multivariable adjusted associations of urbanicity and all covariates in the final model with infant sleep duration at 1 year (minutes/day).

	Estimate (95% CI)
Urbanicity	
Quintile 1	0.0 (ref)
Quintile 2	−3.49 (−19.8, 12.86)
Quintile 3	−11.4 (−27.8, 5.07)
Quintile 4	−11.9 (−28.9, 5.05)
Quintile 5	−19.2 (−37.0, −1.50)
Mother and family	
Maternal age at enrollment (years)	−1.76 (−3.08, −0.44)
College graduate or more	
No	−2.59 (−16.8,11.59)
Yes	0.0 (ref)
Household income	
< $40,000/year	−16.8 (−37.2, 3.62)
$40,000–70,000/year	−9.97 (−24.0, 4.07)
> $70,000/year	0.0 (ref)
Parity	
0	−10.5 (−28.2, 7.33)
1	0.16 (−17.0,17.35)
2+	0.0 (ref)
Married or co-habitation	
No	−23.6 (−49.0, 1.80)
Yes	0.0 (ref)
Maternal smoking status	
Never	0.0 (ref)
Former	6.20 (−7.17, 19.56)
Smoked during pregnancy	4.97 (−14.5, 24.46)
Race/ethnicity	
White	0.0 (ref)
Black	−43.1 (−63.5, −22.8)
Hispanic	−43.9 (−68.0, −19.8)
Other	−21.4 (−41.1, −1.80)
Child and Home Environment	
Sex	
Male	−5.00 (−15.7, 5.71)
Female	0.0 (ref)
Gestational age at birth (weeks)	0.93 (−2.06, 3.92)
Birth weight for gestational age z-score (units)	1.54 (−4.46, 7.55)
Television viewing at 1 year of age (hrs/day)	−5.89 (−9.66, −2.12)